I.M.

OPERATION AND SERVICE MANUAL

FOR

GMC TYPE 450

MICROWAVE POWER METER

GENERAL MICROWAVE
CORPORATION
147 GAZZA BOULEVARD • FARMINGDALE NEW YORK

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SECTION I - GENERAL

1.1 DESCRIPTION

The GMC Type 450 Power Meter is a portable, temperature-compensated, manually balanced, direct current substitution bridge. The meter is designed to measure the average amplitude of cw, modulated, and pulsed microwave power in the range of 0.5 microwatt to 10 milliwatts. Measurements are accurate to within ±0.5 percent of the full scale indication in all ranges. This high accuracy is obtained by using a precision, constant direct current power source and a self-contained, direct-reading potentiometric system of measurement.

When the power meter is used with the GMC 402 Series Temperature-Compensated Waveguide and Coaxial Thermistor Mounts, thermal drift is less than 2 microwatts per degree centigrade. The meter has been designed specifically to operate with these thermistor mounts, but it can be used with any of the wide variety of available bolometers which have either 100- or 200- ohm resistances and have either positive or negative temperature coefficients. To the extent that thermal drift may occur when using the latter types of bolometers, some loss in measurement accuracy may occur.

1.2 ELECTRICAL AND MECHANICAL SPECIFICATIONS

1.2.1 POWER RANGE: Five ranges with full-scale indications of 0.1, 0.3, 1.0, 3.0 and 10 milliwatts and dbm indication of -30 to +10 dbm

1.2.2 FREQUENCY RANGE: Dependent only on external bolometer

1.2.3 BIAS CURRENT: 0 to 16 milliamperes (variable)

1.2.4 ACCURACY: ±0.5 percent of full scale indication

1.2.5 THERMAL DRIFT: Less than $2\mu w/^{\circ}C$ (with GMC 402 Series Thermistor Mounts)

1.2.6 SCALE LENGTH: 12 inches

1.2.7 SCALE RESOLUTION: Approximately 0.1 percent of full scale indication

1.2.8 INPUT POWER: 117v a.c. ±10 percent, 50 to 1000, cycles, approximately 55 watts

1.2.9 DIMENSIONS: 7-1/2" w x 11-1/2" h x 14" d

1.2.10 WEIGHT: 18 lbs.

FIGURE 1 GMC TYPE 450 MICROWAVE POWER METER

SECTION II - OPERATING INSTRUCTIONS

2.1 OPERATING CONTROLS

All controls necessary for the operation of the power meter are described in the following paragraphs. The controls are on the front panel, and are shown in figure 1, unless otherwise stated.

2.1.1 LINE: The LINE switch controls the application of the a.c. input power to the power meter.

2.1.2 BOLO RES: The BOLO RES switch provides adjustment of the power meter for use with 100- or 200- ohm bolometers.

2.1.3 RANGE: The RANGE switch provides selection of the RF power range of the power meter.

2.1.4 BIAS: The BIAS switch provides adjustment of the amplitude of the a.c. bias current in 11 increasing steps. (≈27 kc BIAS FREQ.)

2.1.5 COARSE BIAS: The COARSE BIAS control provides adjustment of the amplitude of the a.c. bias current over the range selected by the BIAS switch.

2.1.6 FINE BIAS: The FINE BIAS control provides precise adjustment of the amplitude of the a.c. bias current.

2.1.7 BAL/BIAS/READ: The BAL/BIAS/READ switch provides selection of the bridge-balancing and power-measuring functions of the power meter.

2.1.8 COMP/UNCOMP 1-2-3: The COMP/UNCOMP 1-2-3 switch provides for selection of the power meter operation with temperature-compensated thermistors or uncompensated bolometers. This switch is at the rear of the power meter.

2.1.9 BALANCE: The BALANCE control provides reactive balancing of the RF bridge when using uncompensated bolometers. This control is at the rear of the power meter.

2.1.10 CALIBRATED DIAL: The front-panel calibrated dial provides precise adjustment of the direct current through the RF bridge. The dial is calibrated in milliwatts and dbm and directly indicates the magnitude of the RF power applied to the bolometer.

2.1.11 NULL INDICATOR: The NULL INDICATOR provides a direct indication of the balance of the RF bridge.

2.2 POWER MEASUREMENTS WITH TEMPERATURE-COMPENSATED BOLOMETERS

2.2.1 LINE: Set the LINE switch to the up position.

2.2.2 BOLO RES: Set the BOLO RES switch to the position corresponding to the resistance of the bolometer.

2.2.3 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to BIAS.

2.2.4 RANGE: Set the RANGE switch to the appropriate range for the power to be measured.

2.2.5 BIAS: Set the BIAS switch to OFF.

2.2.6 COARSE BIAS: Rotate the COARSE BIAS control fully counterclockwise.

2.2.7 COMP/UNCOMP 1-2-3: Set the COMP/UNCOMP 1-2-3 switch to COMP.

2.2.8 INPUT: Connect the cable from the bolometer to the INPUT receptacle.

2.2.9 BIAS: Rotate the BIAS control clockwise until the pointer of the NULL INDICATOR swings from left to right past the null mark, then rotate the BIAS control one step counterclockwise. (8 OR 9 POSIT)

NOTE

When using low-power barretters, rotate the BIAS control clockwise one step and proceed to step 2.2.10 If a null is not reached, return the COARSE BIAS control to its fully counterclockwise position and rotate the BIAS control another step clockwise. Proceed in this manner until a null is reached. Failure to observe this precaution may result in burnout of the detector element.

2.2.10 COARSE BIAS: Rotate the COARSE BIAS control clockwise for an approximate null indication on the NULL INDICATOR.

2.2.11 FINE BIAS: Rotate the FINE BIAS control for an exact null indication on the NULL INDICATOR.

2.2.12 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to READ.

2.2.13 RF POWER: Apply the RF power to be measured to the bolometer.

2.2.14 CALIBRATED DIAL: Rotate the calibrated dial until a null indication is obtained on the NULL INDICATOR. The RF power is indicated directly in milliwatts on the black scale of the calibrated dial. The RF power in dbm is the algebraic sum of the number indicated on the red scale of the calibrated dial and the dbm setting of the RANGE switch.

2.3 POWER MEASUREMENTS WITH UNCOMPENSATED BOLOMETERS

2.3.1 LINE: Set the LINE switch to the up position.

2.3.2 BOLO RES: Set the BOLO RES switch to the position corresponding to the resistance of the bolometer.

2.3.3 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to BIAS.

2.3.4 RANGE: Set the RANGE switch to the 0.1 MW range.

2.3.5 BIAS: Set the BIAS switch to OFF.

2.3.6 COARSE BIAS: Rotate the COARSE BIAS control fully counterclockwise.

2.3.7 COMP/UNCOMP 1-2-3: Set the COMP/UNCOMP 1-2-3 switch to UNCOMP 3.

2.3.8 INPUT: Connect the cable from the bolometer to the INPUT receptacle.

2.3.9 BIAS: Rotate the BIAS control clockwise until the pointer of the NULL INDICATOR swings from left to right past the null mark, then rotate the BIAS control one step counterclockwise.

NOTE

When using low-power barretters, rotate the BIAS control only one step clockwise and proceed to step 2.3.10. If a null is not reached, return the COARSE BIAS control to its fully counterclockwise position and rotate the BIAS control another step clockwise. Proceed in this manner until a null is reached. Failure to observe this precaution may result in burnout of the detector element.

2.3.10 COARSE BIAS: Rotate the COARSE BIAS control for an approximate null indication on the NULL INDICATOR.

2.3.11 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to BAL.

2.3.12 COARSE BIAS: Rotate the COARSE BIAS control for the best null indication; i.e., maximum deflection to the right. (The null indicator needle will remain to the left of center during this step.)

2.3.13 BALANCE: Adjust the BALANCE control for the best null indication as in 2.3.12. Repeat 2.3.12 and 2.3.13 as necessary to obtain the best null indication.

2.3.14 COMP/UNCOMP 1/2/3: If the pointer of the NULL INDICATOR does not pass through a "best null" as described in 2.3.12 when adjusting the BALANCE control, set the COMP/UNCOMP 1/2/3 switch to UNCOMP 2 and proceed as in 2.3.12 and 2.3.13.

2.3.15 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to BIAS.

2.3.16 COARSE BIAS: Adjust the COARSE BIAS control for an approximate null indication.

2.3.17 FINE BIAS: Adjust the FINE BIAS control for an exact null indication.

2.3.18 BAL/BIAS/READ: Set the BAL/BIAS/READ switch to READ.

2.3.19 RF POWER: Apply the RF power to be measured to the bolometer.

2.3.20 CALIBRATED DIAL: Rotate the calibrated dial until a null indication is obtained on the NULL INDICATOR. The RF power is indicated in the manner described in paragraph 2.2.14.

2.4 POWER METER AND BOLOMETER STABILIZATION

The GMC Type 450 Power Meter exhibits drift of less than 2 microwatts per degree centigrade over a wide temperature range when used with the GMC 402 Series of temperature-compensated thermistor mounts. [To achieve the highest accuracy obtainable from the power meter, it should be given a 10- to 15-minute warmup period when using the higher power ranges and a 30-minute warmup period when using the lower power ranges, before making any power measurements.]

WARM UP INFO

When using temperature-compensated thermistor mounts, the mount should be in thermal equilibrium with the transmission line to which it is connected. Once this condition is achieved, the temperature-compensating circuits in the power meter compensate for temperature changes, and the high accuracy of the power meter is maintained.

If uncompensated bolometer mounts are used, the bolometer mount and the transmission line to which it is connected should also be in thermal equilibrium before making a power measurement. The actual measurement should be made as soon as possible after the power meter has been balanced, to prevent slight temperature changes from affecting the accuracy of the measurement.

2.5 BOLOMETER CONNECTION

To prevent damage to the bolometer, it is essential that the BIAS switch be set to OFF and that the COARSE BIAS control be rotated fully counterclockwise before connecting the cable from the bolometer to the power meter. This applies especially to platinum wire barretters which have a very low overload factor. Low-power barretters are nominally biased at 4.5 milliamperes. This current is available in the first position of the BIAS switch; it must not be exceeded when using bolometers of this type. Higher power barretters are nominally biased at 8.75 milliamperes, which is available in the second, third, and fourth positions of the BIAS switch. The higher current positions of the switch are normally used with thermistor-type bolometers.

In all cases, the current should not be increased until it has been determined with complete certainty that the power meter cannot be balanced at a lower current.

2.6 BOLOMETER CHARACTERISTICS

2.6.1 GENERAL The GMC Type 450 Power Meter has been designed specifically for use with bolometers of the temperature-compensated, thermistor type such as the GMC 402 Series Temperature-compensated, Waveguide and Coaxial Thermistor Mounts. Full accuracy of the power meter is obtained with these bolometers. The design of the power meter also permits its use with any 100- or 200- ohm, uncompensated, positive-or negative-coefficient bolometer. When using these bolometers, some degradation in performance may occur because of thermal drift.

2.6.2 TEMPERATURE-COMPENSATED THERMISTOR MOUNTS The GMC 402 Series Temperature-Compensated Thermistor Mounts are designed for use with the GMC Type 450 Power

Meter. Extremely low thermal drift is maintained by using a dual thermistor bridge system in the mounts. The two thermistors are housed close to each other to insure equal thermal environment and good tracking characteristics. When using the Type 450 Power Meter with the 402 Series of bolometers, thermal drift is less than 2 microwatts per degree centigrade. The overall characteristics of the 402 Series of bolometers are shown in figure 2.

2.6.3 UNCOMPENSATED THERMISTOR MOUNTS Thermistors, which have a negative temperature coefficient, are constructed of a small amount of a semiconductor material. Compared to other bolometers, thermistors have a longer time constant and higher sensitivity. They can tolerate a greater overload condition and, in general, have a longer service life. The overall characteristics of the GMC Series 401 Uncompensated Thermistor Mounts are shown in figure 2.

2.6.4 BARRETTERS Barretters, which have a positive temperature coefficient, are usually constructed of very fine platinum wire or thin metal film. They have a shorter time constant than thermistors; consequently they are able to follow high frequency modulation envelopes. This characteristic, combined with their excellent square law behavior, makes them useful as detectors for measuring attenuation, but limits their usefulness as bolometers. The sensitivity of most barretters is within the range of 4 to 10 ohms per milliwatt. The GMC Model N401 bolometer mount can be used with a 4.5-ma barretter (GMC Model 408), with an 8.75-ma barretter (GMC Model 409), or with a thermistor element.

2.7 MEASUREMENT OF MODULATED POWER

Because the GMC Type 450 Power Meter uses direct current substitution and a system of synchronous a.c. null detection, no error is directly attributable to the presence of modulation of the RF signal being measured. This is true, not only of high modulation rates, but of low rates approaching the bolometer time constant. However, there are two sources from which error can affect the accuracy of the power meter. First, when the PRF of the equipment being tested is a subharmonic of the bias oscillator frequency, there may be beating effects which cause an uncertainty of the indication of the bridge balance; second, when the modulating frequency is low enough for the null amplifier to follow the modulation envelope, it may also cause an uncertainty of the indication of the bridge balance. This low frequency limit is in the order of 10 cycles.

GMC Model Number		Frequency Range (GC)	Waveguide Size	Waveguide Type	Flange Type	Maximum VSWR	Resistance (ohms)
Uncompensated	Temperature-Compensated						
N 401	N 402	0.01-10.0	3/8" coax.	--	Type N Male	1.5	200
S 401	S 402	2.6-3.95	3 x 1 1/2	RG-48/U	UG-53/U	1.35	100
G 401	G 402	3.95-5.85	2 x 1	RG-49/U	UG-194/U	1.5	100
C 401	C 402	5.3-8.2	1 1/2 x 3/4	RG-50/U	UG-344/U	1.5	100
J 401	J 402	7.05-10.0	1 1/4 x 5/8	RG-51/U	UG-51/U	1.5	100
X 401	X 402	8.2-12.4	1 x 1/2	RG-52/U	UG-39/U	1.5	100
U 401	U 402	12.4-18.0	WAS 0.622x0.311 ✓.702x.391	RG-91/U	UG-419/U	1.5	100
K 401	K 402	18.0-26.5	WAS 0.420 x0.170 ✓.500x.250	WAS RG-53/U ✓RG-66/U	UG-595/U	2.0	200
A 401	A 402	26.5-40.0	WAS 0.280 x0.140 ✓.360x.220	RG-96/U	UG-599/U	2.0	200

FIGURE 2 NOMINAL CHARACTERISTICS OF RECOMMENDED THERMISTOR MOUNTS

SECTION III - THEORY OF OPERATION

3.1 GENERAL CIRCUIT DESCRIPTION

The block diagram of the GMC Type 450 Power Meter is shown in figure 3. When the power meter is connected to an external temperature-compensated thermistor mount, a thermistor in the mount is connected across one leg of the RF bridge. A constant direct current from the precision constant-current supply is applied across the parallel combination of the RF bridge and a calibrated rheostat. The magnitude of the direct current through the RF bridge is established by the calibrated rheostat. An a.c. bias current is generated in the bias oscillator circuit and is applied through an adjustable attenuator network. The output of the attenuator is applied to the RF bridge with the calibrated direct current. The amplitude of the a.c. bias current applied to the RF bridge controls the resistance of the thermistor. The attenuator is adjusted so that the resistance of the thermistor is equal to 100 or 200 ohms as required. When this condition exists, the bridge is balanced and the two inputs to the differential amplifier are equal. The two input signals are amplified by the differential amplifier and are coupled to the synchronous detector. With equal signals applied to the synchronous detector there is no output, and a null indication is shown on the null indicator.

When external RF power is applied to the bolometer, the resistance of the thermistor is changed and the RF bridge becomes unbalanced. This unbalanced condition causes an unbalance of the input signals to the differential amplifier. The signals are amplified by the differential amplifier and are coupled to the synchronous detector. With unequal signals applied

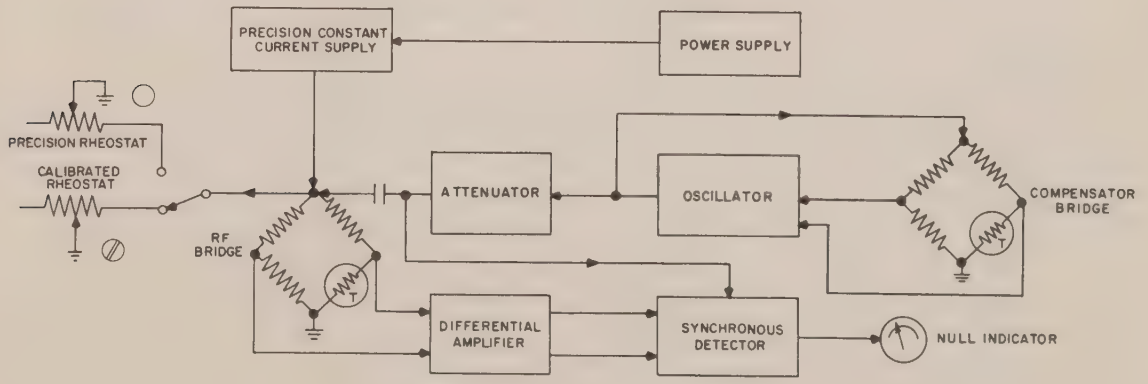

FIGURE 3 SIMPLIFIED BLOCK DIAGRAM

to the synchronous detector, an output signal is produced which causes a deflection of the pointer of the null indicator.

When measuring RF power, a precision rheostat is switched into the circuit in place of the calibrated rheostat. By adjusting the resistance of the precision rheostat, the direct current through the RF bridge can be varied. The change of direct current through the RF bridge causes the resistance of the thermistor in the bolometer to change. The precision rheostat is adjusted so that the resistance of the thermistor is again equal to 100 or 200 ohms. This occurs when the d.c. current removed from the RF bridge is equal to the applied RF power.

When this condition is reached, the input signals to the differential amplifier are equal, and a null indication is shown on the null indicator. A dial, directly connected to the precision rheostat, is calibrated in milliwatts and dbm and indicates the RF power applied to the bolometer.

Bolometer sensitivity to ambient temperature changes is compensated for by a dual bridge system. The compensating bridge contains a thermistor whose characteristics parallel those of the RF thermistor. The thermistors are located in the same thermal environment in the bolometer mount and respond to environmental influences identically. The compensating thermistor causes the amplitude of the bias oscillator output to change. This change is in such a direction as to correct the resistance of the RF thermistor and maintain the static balance of the RF bridge.

When uncompensated bolometers are used, a thermistor in the power meter is switched into the compensating bridge in place of the external thermistor in the bolometer mount.

3.2 POWER SUPPLY

The power supply consists of a full-wave rectifier with a series regulator section with positive ground. The rectifier consists of transformer T101, rectifier tube V104, and filter capacitor C126A. The series regulator consists of series regulator tube V106, control amplifier tube V107, and voltage reference tube V108. (See figure 4.)

The amplitude of the output voltage from the power supply is controlled by the action of series regulator tube V106. If the output voltage tends to increase, the voltage on the grid of control amplifier tube V107B becomes more positive. The voltage on the cathode of tube V107B is held constant by voltage reference tube V108. The increased positive voltage on the grid of tube V107B causes the tube to increase conduction, which causes the cathode voltage of tube V107A to decrease. This action causes tube V107A to increase conduction, and to increase the voltage drop across resistor R177. The increased voltage drop across resistor R177 lowers the plate

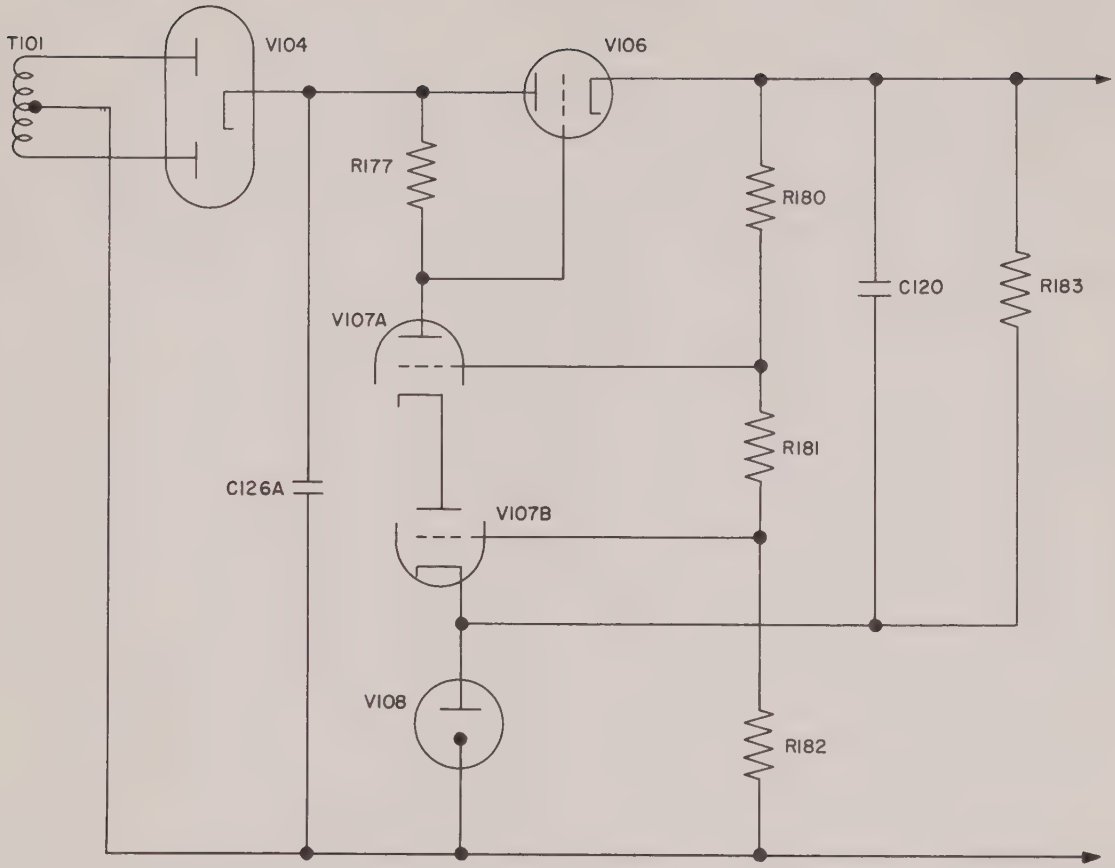

FIGURE 4 SIMPLIFIED SCHEMATIC DIAGRAM OF POWER SUPPLY

voltage of tube V107A. This voltage is the grid voltage for series regulator tube V106. The decreased grid voltage of tube V106 causes its plate resistance to increase. The increased plate resistance of tube V106 causes the voltage drop across the tube to increase and to lower the power supply output voltage. The sequence of effects is reversed if the power supply output voltage tends to decrease.

3.3 CONSTANT CURRENT SUPPLY

The constant current supply consists of series regulator tube V113, control amplifier tube V112, differential tube V111, and voltage reference tube V109. (See figure 7.)

The magnitude of the output current from the constant current supply is selected by RANGE switches S106A and S106B. If the magnitude of the

selected current tends to increase, the voltage on the cathode of series regulator tube V113A becomes less negative. This decreased negative voltage is applied to the grid of tube V111B and causes the tube to increase conduction. The cathode of V111 becomes less negative. The grid of tube V111A is held at a constant voltage by voltage reference tube V109. The less negative voltage on the cathode of tube V111 causes the plate voltage to become less negative. The plate voltage of tube V111A is the grid voltage of tube V112B. When the plate voltage of tube V111A becomes negative, tube V112B increases conduction and its plate voltage becomes more negative. This voltage is applied to the grid of series regulator tube V113A. The more negative grid voltage causes tube V113A to decrease conduction and to return the selected current to the original amplitude. The sequence of effects is reversed if the selected output current tends to decrease.

3.4 BIAS OSCILLATOR

Tube V101, the bias oscillator, provides the a.c. bias current required for balancing the RF bridge before RF power is applied. The oscillator operates at a frequency of approximately 27 kc, determined by coil L101 and capacitors C105 and C106. Feedback for operation of the oscillator is provided through resistor R111, the compensator bridge, and capacitor C101. When compensated bolometers are used, an external thermistor is switched into the compensator bridge. This thermistor controls the amplitude of the feedback signal to the oscillator. When uncompensated bolometers are used, thermistor RT101 is switched into the compensator bridge and controls the amplitude to the feedback signal. The amplitude of the feedback signal controls the amplitude of the output signal from the oscillator.

The output signal from the bias oscillator is applied to an attenuator network controlled by BIAS switch S101. The output of the attenuator is applied across potentiometer R115, the COARSE BIAS control. The a.c. bias current from potentiometer R115 is coupled by capacitor C127 to the RF bridge network. The FINE BIAS control, potentiometer R142, is connected in parallel with capacitor C127 and the RF bridge network. Potentiometer R142 shunts a portion of the a.c. bias current to ground, providing a precise adjustment of the a.c. bias current.

3.5 RF BRIDGE NETWORK

Figure 5 illustrates the RF bridge connected for operation with 200-ohm bolometers. The output of the constant current supply is applied to the RF bridge and to precision rheostat R150. Rheostat R150 controls the magnitude of the d.c. current through the bridge. The a.c. bias current from the bias oscillator is coupled to the bridge by capacitor C127. The a.c. voltages developed across resistor R146 and the bolometer are coupled to the meter circuit to indicate the balance condition of the bridge. When the thermistor is initially connected to the bridge and RF power is not

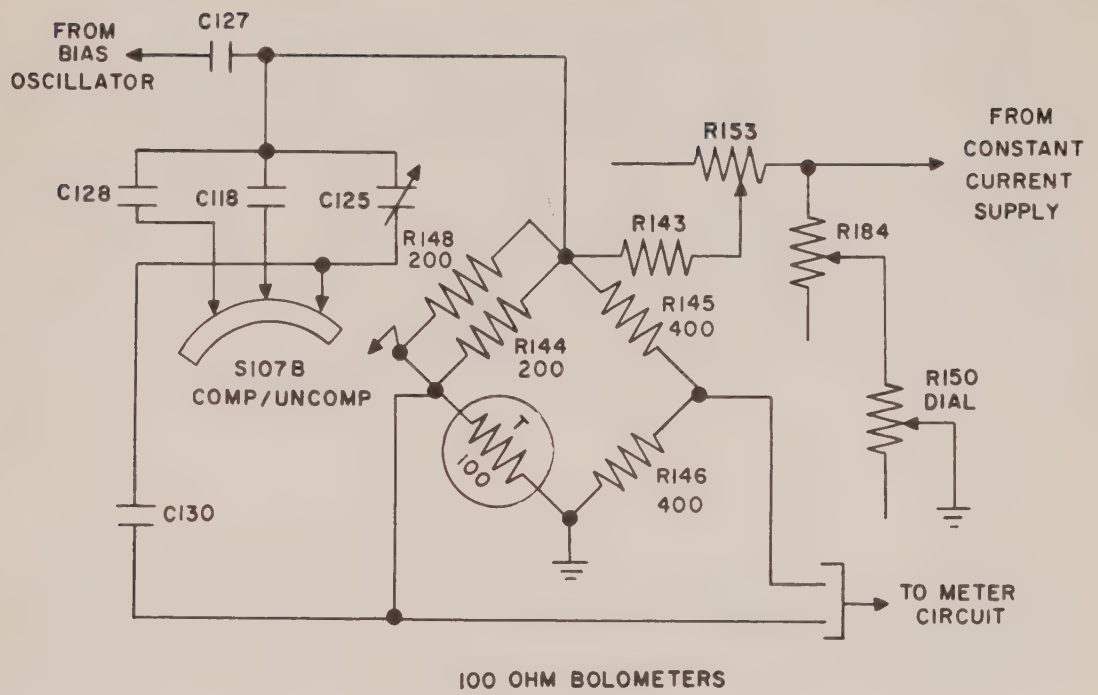

FIGURE 5 SIMPLIFIED SCHEMATIC DIAGRAM OF RF BRIDGE NETWORK

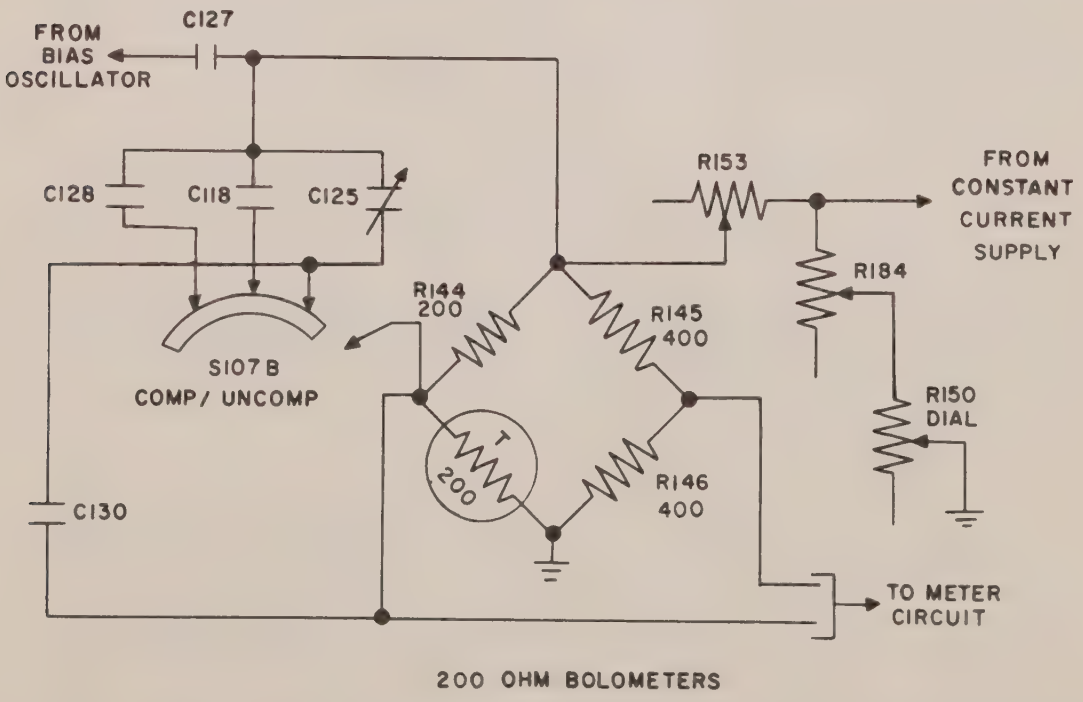

FIGURE 6 SIMPLIFIED SCHEMATIC DIAGRAM OF RF BRIDGE NETWORK

applied, the a.c. bias current is adjusted to bring the resistance of the bolometer to 200 ohms. When RF power is applied, the resistance of the thermistor changes and the a.c. voltages to the meter circuit become unbalanced. Resistor R150 is adjusted to reduce the d.c. current through the thermistor and return its resistance to 200 ohms.

When 100-ohm bolometers are used, the operation of the bridge circuit is identical with that described for 200-ohm bolometers. Resistor R148 is connected in parallel with resistor R144 to adjust the bridge for 100-ohm bolometers. (See figure 6.)

Capacitors C118, C128, C125 and C130 provide for reactive balancing of an uncompensated bolometer.

3.6 METER CIRCUIT

The meter circuit consists of differential amplifier tubes V103 and V105, synchronous detector tube V102, and meter M101. (See figure 7.)

The a.c. voltages on opposite sides of the RF bridge are coupled to differential amplifier tube V105 by capacitors C116 and C117. The a.c. signals are amplified by tube V105 and are coupled to differential amplifier tube V103 by capacitors C114 and C115. The a.c. signals are amplified by tube V103 and are coupled to synchronous detector tube V102. The amplification of the signals by differential amplifier tube V103 is controlled by RANGE switch S106E. An a.c. signal from the output circuit of the bias oscillator is coupled by capacitor C111 to the grids of synchronous detector tube V102. This signal is amplified by the synchronous detector. The amplitude of the a.c. signals in the plate circuits of the synchronous detector is a function of the amplitude of the a.c. signals from differential amplifier tube V103. The a.c. signals from the plate circuits of the synchronous detector are coupled to a detector circuit consisting of diodes CR101 and CR102. The a.c. signals are rectified and the d.c. voltages produced are developed across resistors R172 and R173. These d.c. voltages are applied across meter M101.

If the RF bridge is balanced, the a.c. signals in the meter circuit are equal and the d.c. voltages developed across resistors R172 and R173 will be equal. When the d.c. voltages are equal, no voltage difference exists across meter M101 and a null indication is presented. If the RF bridge is unbalanced, the a.c. signals in the meter circuit are unequal and the d.c. voltages developed across resistors R172 and R173 will be unequal. When the d.c. voltages are unequal, a voltage difference exists across meter M101 and the pointer deflects to the right or left, indicating an unbalanced condition of the RF bridge.

SECTION IV - CALIBRATION

4.1 GENERAL

Before the power meter is shipped from the factory, it is calibrated against d.c. transfer standards traceable to the National Bureau of Standards. If it is necessary to calibrate the meter, the procedure given in this section should be followed, using the recommended test equipment.

4.2 TEST EQUIPMENT REQUIRED FOR CALIBRATION

The accuracy of the power meter depends on the accuracy of the test equipment used for calibrating it. The following test equipment and accessories, or equivalent, are recommended.

4.2.1 Digital D-C Vacuum Tube Voltmeter - John Fluke Co., Model 801

4.2.2 Oscilloscope - Hewlett-Packard Co., Model 130B

4.2.3 Variac - Powerstat, Model 116

4.2.4 Precision resistor, 100-ohm ±0.1%, 1/2-watt

4.2.5 Phone plug "A", Switchcraft Type 190A

4.2.6 Phone plug "B", Switchcraft Type 440

4.3 POWER SUPPLY PERFORMANCE CHECK

To check the performance of the rectifier and series regulator in the power supply, proceed as follows:

4.3.1 Connect the power meter to the Variac, and adjust the Variac for an output voltage of 117 volts a.c.

4.3.2 Set the LINE switch on the power meter to the up position.

4.3.3 Set the RANGE switch to 10 MW.

4.3.4 Connect the digital vtvm between test point A and ground; the digital vtvm should indicate -188 to -206 volts d.c.

4.3.5 Vary the output voltage from the Variac from 105 to 128 volts a.c.; the vtvm indication should not vary more than ±0.4 volt d.c.

4.3.6 Disconnect the digital vtvm and connect the oscilloscope to test point A; the oscilloscope should indicate an a.c. ripple of less than 15 millivolts peak-to-peak on the power supply output voltage.

4.3.7 Disconnect the oscilloscope.

4.4 CONSTANT CURRENT SUPPLY CALIBRATION

To calibrate the constant current supply, proceed as follows:

4.4.1 Set the RANGE switch to 1.0 MW.

4.4.2 Set the BOLO RES switch to 200.

4.4.3 Insert phone plug "A" into jack J102.

4.4.4 Connect the digital vtvm between test point B and ground.

4.4.5 Adjust potentiometer R151 for an indication of -2.1237 volts on the digital vtvm.

4.4.6 Set the BOLO RES switch to 100.

4.4.7 Observe and record the indication on the digital vtvm. The voltage indicated should be -2.5028 volts ±0.1%. Record the error.

4.4.8 Readjust potentiometer R151 for an indication of -2.5028 volts ±one-half the error recorded in step 4.4.7.

4.4.9 Rotate the RANGE switch to each position and observe the indication on the digital vtvm; the voltage must correspond to the voltage given in the following table for each position of the RANGE switch.

RANGE SWITCH	VOLTAGE
0.1 MW	-0.79146±0.2%
0.3 MW	-1.40745±0.2%
1.0 MW	-2.50280±0.1%
3.0 MW	-4.45072±0.2%
10.0 MW	-7.91460±0.2%

4.4.10 Set the RANGE switch to 10 MW.

4.4.11 Vary the output voltage from the Variac from 105 to 128 volts a.c.; the voltage indicated on the digital vtvm must not vary more than ± 0.1%.

4.4.12 Disconnect the digital vtvm.

4.4.13 Remove phone plug "A" from jack J102.

4.5 AUTOMATIC ZERO ADJUSTMENT

To adjust the automatic zero potentiometer, proceed as follows:

4.5.1 Rotate the calibrated dial fully counterclockwise. Check the alignment of the dial index line with the 1.0-milliwatt and 0-dbm marks on the calibrated dial. If the alignment is incorrect, loosen the two screws which hold the dial index. Align the dial index line with the 1.0-milliwatt and 0-dbm marks on the calibrated dial, and tighten the two screws.

4.5.2 Rotate the calibrated dial to 0 milliwatts.

4.5.3 Set the BAL/BIAS/READ switch to READ.

4.5.4 Insert phone plug "B" into jack J103.

4.5.5 Connect the digital vtvm between test point C and ground.

4.5.6 Observe and record the indication of the digital vtvm.

4.5.7 Set the BAL/BIAS/READ switch to BIAS.

4.5.8 Adjust potentiometer R149 for the same indication on the digital vtvm that was recorded in step 4.5.6.

4.6 MAXIMUM POWER CALIBRATION

To adjust the maximum power potentiometer, proceed as follows:

4.6.1 Set the BAL/BIAS/READ switch to READ.

4.6.2 Rotate the calibrated dial to 1.0 milliwatts.

4.6.3 Observe and record the indication of the digital vtvm.

4.6.4 Substitute the voltages obtained in steps 4.5.6 and 4.6.3 in the following formula, and solve for E_A.

$$E_A = 0.15645 (E_1 - E_2)$$

where E_1 equals the voltage recorded in step 4.5.6 and E_2 equals the voltage recorded in step 4.6.3.

4.6.5 Adjust potentiometer R184 for an indication on the digital vtvm equal to the voltage (E_A) calculated in step 4.6.4.

4.6.6 Remove phone plug "B" from jack J103.

4.7 MINIMUM POWER CALIBRATION

To adjust the minimum power potentiometer, proceed as follows:

4.7.1 Connect a 100-ohm ±0.1% resistor between pin 1 of jack J101 and ground.

4.7.2 Insert phone plug "A" into jack J102.

4.7.3 Set the BAL/BIAS/READ switch to READ.

4.7.4 Substitute the voltages recorded in step 4.5.6 and 4.6.3 in the following formula, and solve for E_B.

$$E_B = 0.57822 (E_1 - E_2)$$

where E_1 equals the voltage recorded in step 4.5.6 and E_2 equals the voltage recorded in step 4.6.3.

4.7.5 Adjust potentiometer R153 for an indication on the digital vtvm equal to the voltage (E_B) calculated in step 4.7.4.

4.7.6 Remove phone plug "A" from jack J102.

4.7.7 Disconnect the digital vtvm and the Variac.

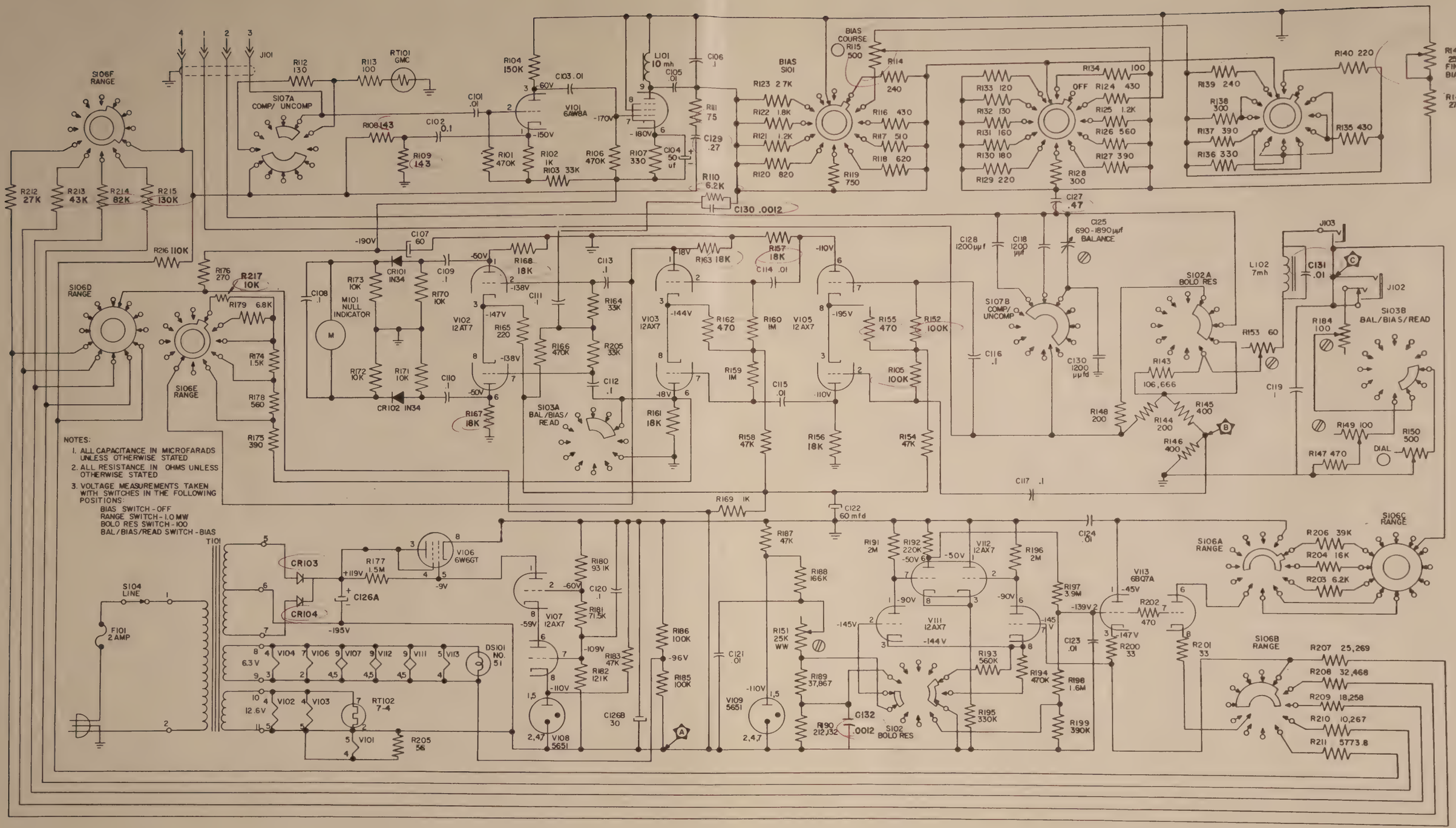

FIGURE 7 SCHEMATIC DIAGRAM OF GMC TYPE 450 POWER METER

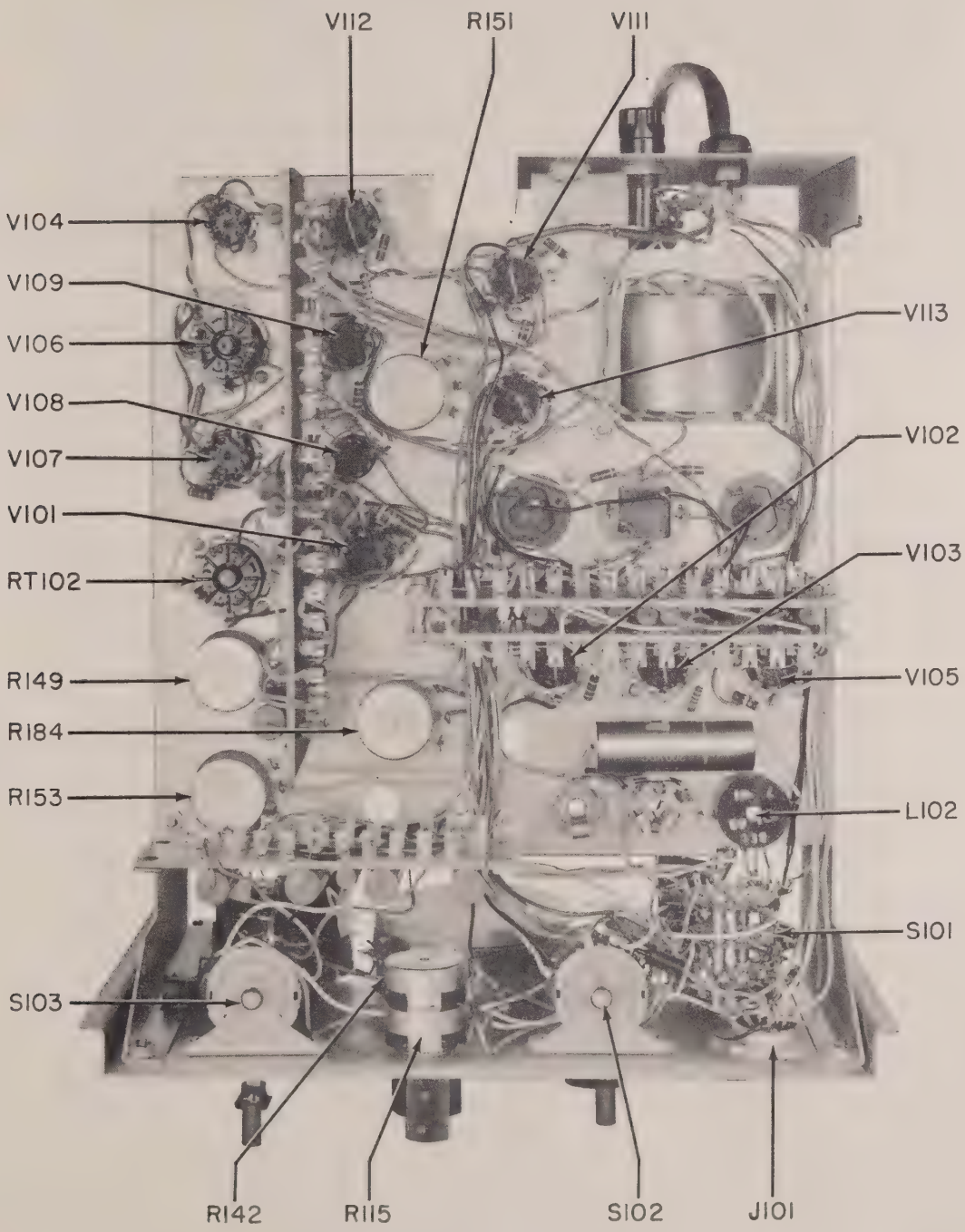

FIGURE 8 RIGHT SIDE VIEW WITH COVER REMOVED

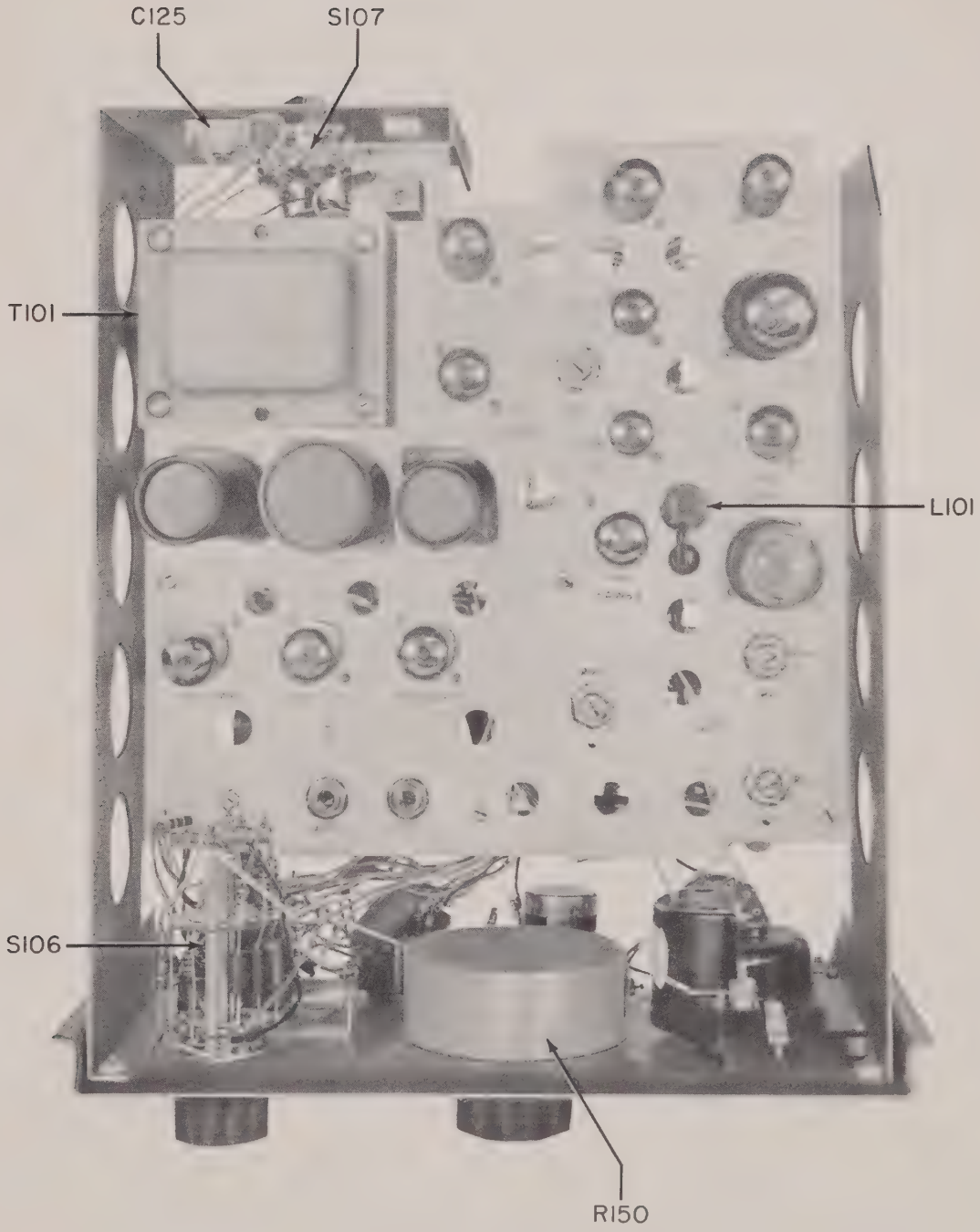

FIGURE 9 LEFT SIDE VIEW WITH COVER REMOVED

SECTION V - TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
C101	Capacitor: fixed, molded paper, .01μf., ±10%, 400 vdcw	8	M	
C102	Capacitor: fixed, molded paper 0.1 uf., ±10% 400 vdcw	11	M	
C103	Same as C101			
C104	Capacitor: electrolytic, 50μf., 6 vdcw	1	M	
C105	Capacitor: fixed, molded paper, .01μf., ±5%, 400 vdcw	1	M	
C106	Same as C102			
C107	Capacitor: electrolytic, 60μf., 300 vdcw	2	F	
C108	Same as C102			
C109	Same as C102			
C110	Same as C102			
C111	Same as C102			
C112	Same as C102			
C113	Same as C102			
C114	Same as C101			
C115	Same as C101			
C116	Same as C102			
C117	Same as C102			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
C118	Capacitor: fixed, ceramic disc, 1,200 μμf., ± 20%, 600 vdcw	5	F	
C119	Capacitor: fixed, molded paper, 1.0μf., ±10%, 200 vdcw	1	M	
C120	Same as C102			
C121	Same as C101			
C122	Same as C107			
C123 C124	Same as C101			
C125	Capacitor: padder, compression mica; 650-1, 890μμf., 250 vdcw	1	C	
C126A, C126B	Capacitor: electrolytic, 50-30μf., 350 vdcw	1	F	
C127	Capacitor: fixed, molded paper o.47 uf., ±10%, 400 vdcw	1	M	
C128	Same as C118			
C129	Capacitor: fixed, molded paper 0.27 uf., ±10%, 400 vdcw	1	M	
C131	Same as C101			
C130C132	Same as C118			
C133	Same as C118			
CR101	Rectifier: crystal, Type 1N34	2		
CR102	Same as CR101			
CR103	Rectifier: silicon diode, type B295			
CR104	Same as CR103			
DS101	Lamp: miniature, bayonet base, Type 51	1	H	
F101	Fuse: Cartridge, 3AG, 2 amp.	1	K	
J101	Connector	1	B	
J102	Jack	1	N	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
J103	Jack	1	N	
L101	Coil	1	I	1387
L102	Coil	1	I	1390
M101	Meter	1	I	1164
R101	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 w.	3	J	
R102	Resistor: fixed, composition, 1,000 ohms, ±5%, 1/2 w.	2	J	
R103	Resistor: fixed, composition, 33,000 ohms, ±5%, 1/2 w.	3	J	
R104	Resistor: fixed, composition, 150,000 ohms, ±10%, 1 w.	1	J	
R105	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 w.	3	J	
R106	Same as R101			
R107	Resistor: wire-wound, 330 ohms, ±5%, 1/2 w.	1	J	
R108	Resistor: deposited carbon, 143 ohms, ±1%, 1/2 w.	2	J	
R109	Same as R108			
R110	Resistor: fixed, composition, 6,200 ohms, ±5%, 1/2 w.	2	J	
R111	Resistor: deposited carbon, 75 ohms, ±1%, 1/2 w.	1	J	
R112	Resistor: wire-wound, 130 ohms, ±5%, 1/2 w.	1	J	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R113	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 w.	1	J	
R114	Resistor: fixed, composition, 240 ohms, ±5%, 1/2 w.	2	J	
R115	Potentiometer: wire-wound, concentric, 500 ohms	1	I	1354
R116	Resistor: fixed, composition, 430 ohms, ±5%, 1/2 w.	3	J	
R117	Resistor: fixed, composition, 510 ohms, ±5%, 1/2 w.	1	J	
R118	Resistor: fixed, composition, 620 ohms, ±5%, 1/2 w.	1	J	
R119	Resistor: fixed, composition, 720 ohms, ±5%, 1/2 w.	1	J	
R120	Resistor: fixed, composition, 820 ohms, ±5%, 1/2 w.	1	J	
R121	Resistor: fixed, composition, 1,200 ohms, ±5%, 1/2 w.	2	J	
R122	Resistor: fixed, composition, 1,800 ohms, ±5%, 1/2 w.	1	J	
R123	Resistor: fixed, composition, 2,700 ohms, ±5%, 1/2 w.	1	J	
R124	Same as R116			
R125	Same as R121			
R126	Resistor: fixed, composition, 560 ohms, ±5%, 1/2 w.	2	J	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R127	Resistor: fixed, composition, 390 ohms, ±5%, 1/2 w.	3	J	
R128	Resistor: fixed, composition, 300 ohms, ±5%, 1/2 w.	3	J	
R129	Resistor: fixed, composition, 220 ohms, ±5%, 1/2 w.	2	J	
R130	Resistor: fixed, composition, 180 ohms, ±5%, 1/2 w.	1	J	
R131	Resistor: fixed, composition, 160 ohms, ±5%, 1/2 w.	1	J	
R132	Resistor: fixed, composition, 130 ohms, ±5%, 1/2 w.	1	J	
R133	Resistor: fixed, composition, 120 ohms, ±5%, 1/2 w.	1	J	
R134	Resistor: fixed, composition, 100 ohms, ±5%, 1/2 w.	1	J	
R135	Same as R116			
R136	Same as R128			
R137	Same as R127			
R138	Same as R128			
R139	Same as R114			
R140	Same as R129			
R141	Resistor: fixed, composition, 27,000 ohms, ±10%, 1/2 w.	1	J	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R142	Potentiometer: concentric, 25,000 ohms	1	I	1354
R143	Resistor: wire-wound, 106.666 ohms, ±0.1%, 1/2 w.	1	L	
R144	Resistor: wire-wound, 200.00 ohms, ±0.1%, 15 w.	2	L	
R145	Resistor: wire-wound, 400.000 ohms, ±0.1%, 15 w.	2	L	
R146	Same as R145			
R147	Resistor: wire-wound, 470 ohms, ±5%, 1/2 w.	1	J	
R148	Same as R144			
R149	Potentiometer: wire-wound, 100 ohms, ±10%, 2 w. linear taper	2	E	
R150	Potentiometer	1	I	1347
R151	Potentiometer: wire-wound, 25,000 ohms ±10%, 2 w., linear taper	1	E	
R152	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 w.	3	J	
R153	Potentiometer: wire-wound, 60 ohms, ±10%, 2 w. linear taper	1	E	
R154	Resistor: fixed, composition, 47,000 ohms, ±5%, 1/2 w.	4	J	
R155	Same as R102			
R156	Resistor: fixed, composition, 18,000 ohms, ±5%, 1/2 w.	6	J	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R157	Same as R156			
R158	Same as R154			
R159	Same as R152			
R160	Same as R152			
R161	Same as R156			
R162	Resistor: fixed, composition, 470 ohms, ±5%, 1/2 w.	1	J	
R163	Same as R156			
R164	Same as R103			
R165	Resistor: fixed, composition, 220 ohms, ±10%, 1/2 w.	1	J	
R166	Same as R101			
R167	Same as R156			
R168	Same as R156			
R169	Resistor: fixed, composition, 1,000 ohms, ± 10%, 1/2 w.	1	J	
R170	Resistor: fixed, composition, 10,000 ohms, ± 5%, 1/2 w.	5	J	
R171	Same as R170			
R172	Same as R170			
R173	Same as R170			
R174	Resistor: fixed, composition, 1,500 ohms, ±5%, 1/2 w.	1	J	
R175	Same as R127			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R176	Resistor: fixed, composition, 270 ohms, ± 10%, 1/2 w.	1	J	
R177	Resistor: fixed, composition, 1.5 megohms, ± 10%, 1/2 w.	1	J	
R178	Same as R126			
R179	Resistor: fixed, composition, 6,800 ohms, ± 10%, 1/2 w.	1	J	
R180	Resistor: fixed, carbon film, 93,100 ohms, ± 1.0%, 1/2 W., epoxy-dipped	1	G	
R181	Resistor: fixed, carbon film, 71,500 ohms, ± 1.0%, 1/2 w. epoxy-dipped	1	G	
R182	Resistor: fixed, carbon film, 121,000 ohms, ± 1.0%, 1/2 w., epoxy-dipped	1	G	
R183	Same as R154			
R184	Same as R149			
R185	Same as R105			
R186	Same as R105			
R187	Same as R154			
R188	Resistor: wire-wound, 160,000 ohms, ±1.0%, 1/2 w.	1	L	
R189	Resistor: wire-wound, 37,867 ohms, ± 0.1%, 15 w.	1	L	

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R190	Resistor: wire-wound, 212,132 ohms, ±0.1%, 15 w.	1	L	
R191	Resistor: fixed, composition, 2 megohms, ±5%, 1/2 w.	2	J	
R192	Resistor: fixed, composition, 220,000 ohms, ± 5%, 1/2 w.	1	J	
R193	Resistor: fixed, composition, 560,000 ohms, ± 5%, 1/2 w.	1	J	
R194	Resistor: fixed, composition, 470,000 ohms, ± 5%, 1/2 w.	1	J	
R195	Resistor: fixed, composition, 330,000 ohms, ± 5%, 1/2 w.	1	J	
R196	Same as R191			
R197	Resistor: fixed, composition, 3.9 megohms, ± 5%, 1/2 w.	1	J	
R198	Resistor: fixed, composition, 1.2 megohms, ± 5%, 1/2 w.	1	J	
R199	Resistor: fixed, composition, 390,000 ohms, ± 5%, 1/2 w.	1	J	
R200	Resistor: fixed, composition, 33 ohms, ±10%, 1/2 w.	2	J	
R201	Same as R200			
R202	Resistor: fixed, composition, 470 ohms, ±10%, 1/2 w.	1	J	
R203	Same as R110			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
R204	Resistor: fixed, composition, 16,000 ohms, ± 5%, 1/2 w.	1	J	
R205	Resistor: fixed, composition, 56 ohms, ±10%, 1 w.	1	J	
R206	Resistor: fixed, composition, 39,000 ohms, ± 5%, 1/2 w.	1	J	
R207	Resistor: wire-wound, 25,269 ohms, ±0.1%, 15 w.	1	L	
R208	Resistor: wire-wound, 23,468 ohms, ±0.1%, 15 w.	1	L	
R209	Resistor: wire-wound, 18,258 ohms, ± 0.1%, 33 w.	1	L	
R210	Resistor: wire-wound, 10,267 ohms, ± 0.1%, 75 w.	1	L	
R211	Resistor: wire-wound, 5,773.8 ohms, ± 0.1%, 1 w.	1	L	
R212	Resistor: fixed, composition, 27,000 ohms, ±5%, 2 w.	1	J	
R213	Resistor: fixed, composition, 43,000 ohms, ± 5%, 1 w.	1	J	
R214	Resistor: fixed, composition, 82,000 ohms, ± 5%, 1/2 w.	1	J	
R215	Resistor: fixed, composition, 130,000 ohms, ±5%, 1/2 w.	1	J	
R216	Resistor: fixed, composition, 110,000 ohms, ± 5%, 1/2 w.	1	J	
R217	Same as R170			
R218	Same as R103			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
RT101	Thermistor: 32BH5	1	I	
RT102	Ballast: 7-4	1	A	
S101	Switch, rotary, 12-position	1	I	1153
S102	Switch, lever, 2-position	1	I	1156
S103	Switch, lever, 3-position	1	I	1155
S104	Switch, toggle, SPST	1	D	
S105	Not used			
S106	Switch, rotary, 5-position	1	I	1154
S107	Switch, rotary, 4-position	1	I	1188
T101	Transformer	1	I	1152
V101	Tube, electron: 6AW8A	1	O	
V102	Tube, electron: 12AT7	1	O	
V103	Tube, electron: 12AX7	5	O	
V104	Not used			
V105	Same as V103			
V106	Tube, electron: 6W6GT	1	O	
V107	Same as V103			
V108	Tube, electron: 5651	2	O	
V109	Same as V108			
V110	Not Used			

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG. NO.
V111	Same as V103			
V112	Same as V103			
V113	Tube, electron: 6BQ7A	1	O	

LIST OF MANUFACTURERS' CODE LETTERS

Code Letter	Manufacturer	Address
A	Amperite Co.	New York, N. Y.
B	Amphenol Connector	Chicago, Ill.
C	Arco Electronics, Inc.	New York, N. Y.
D	Carling Electric, Inc.	Hartford, Conn.
E	Clarostat Manufacturing Co.	Dover, N. H.
F	Cornell-Dubilier Electric Corp.	Plainfield, N. J.
G	Dale Products, Inc.	Columbus, Nebr.
H	General Electric Co.	Schenectady, N. Y.
I	General Microwave Co.	Farmingdale, N. Y.
J	International Resistance Co.	Philadelphia, Pa.
K	Littelfuse, Inc.	Des Plaines, Ill.
L	Marstan Electronics Corp.	New York, N. Y.
M	Sprague Electric Co.	North Adams, Mass.
N	Switchcraft, Inc.	Chicago, Ill.
O	Tung-Sol Electric Co.	Newark, N. J.
P	Erie Resistor Co.	Erie, Pa.
R	Tru-ohm Products	Chicago, Ill.
S	Amperex Electronic Corp.	Hicksville, N.Y.
T	Britton Electronics Corp.	Mt. Vernon, N.Y.

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